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Book review

Molecular Plant Breeding, Y. Xu. CAB International, UK (2010). 734 pp., Hardcover, $240.00, ISBN: 978 1 84593 392 0

"Nevertheless, the number of farmers, small as well as large, who are adopting the new seeds and new technology is increasing very rapidly, and the increase in numbers during the past three years has been phenomenal." – Dr. Norman Borlaug.

This excerpt from Dr. Norman Borlaug's Nobel Lecture at the Nobel Institute in Oslo, Norway, in December 1970 is in reference to the landmark events that sparked the "Green Revolution" in countries of Southern Asia. The adoption of "new seeds" and "new technology" by farmers and plant breeders has continued to play a prominent role. If crop yields are to continually increase in this period of climate change and unprecedented population growth, plant breeders will need to augment "first revolution" technology such as hybrid seed and synthetic fertilizers with newer technologies such as genotyping-by-sequencing, proximal remote sensing for plant phenotyping, and crop simulation modeling. In that light, current and future plant breeders need to be armed with a multitude of skills that are drawn from a variety of scientific disciplines. Of paramount importance, the modern plant breeder will need to know how to make effective use of molecular biology for varietal development. There are few books if any that deliver a careful integration of plant breeding, quantitative genetics, and molecular biology to the reader. Therefore, I welcomed with excitement the opportunity to review *Molecular Plant Breeding* by Dr. Yunbi Xu, the principal maize molecular breeder at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico.

The 15 chapters of *Molecular Plant Breeding* with forewords by Drs. Norman Borlaug and Ronald Phillips are a testament to the expertise that is required by a plant breeder to be productive and competitive in the 21st century. Chapter 1 begins with an introduction to the history of crop domestication and early plant breeding along with terminology and key concepts of quantitative genetics and selection theory, laying a solid foundation for the later chapters. Molecular markers, genetic map construction, and high-throughput 'omics' technologies are discussed in Chapters 2 and 3. The review on single-nucleotide polymorphism (SNP) and other types of molecular markers and their use in plant breeding is exceptional. The absence of a section dedicated to genotyping-by-sequencing is not a neglectful omission by the author, but rather a reflection of the accelerated advancements in the field of genomics. However, the devotion of more than 10 pages to microarray technologies seems excessive because of the likelihood that next-generation DNA sequencing technologies will soon supplant microarrays for the majority of transcriptome studies. Chapter 4 delves into the different population designs that are typically employed in plant genetics and crop improvement. This chapter combines valuable information on the construction of double haploid and recombinant inbred line populations. The application of molecular tools for the management, evaluation, and enhancement of plant genetic resources is covered in Chapter 5 and will be of great interest to any plant germplasm curator overwhelmed by large, potentially redundant collections.

Understanding the genetic basis of complex traits in agricultural crops, most of which are under multigenic control, is vital for meeting the challenge of increased demand for food, feed, fiber, and fuel production. Given their major importance, complex traits are the central theme of the next five chapters and form the keystone of this book. Chapters 6 and 7 concentrate on the theory and practice of complex trait dissection. The statistical theory underlying the various methods of quantitative trait loci (QTL) analysis is very accessible to a non-statistician, but it is not a replacement for the more theoretical *Genetics and Analysis of Quantitative Traits* (Lynch and Walsh, 1998). An unfortunate omission is a section on mixed model theory as it relates to association mapping. The discussion of QTL analysis with multiple crosses is enlightening and will be surely of interest to geneticists and breeders that look to increase statistical power by combining populations. Important, but often overlooked topics such as allele dispersion, multiple QTL alleles, and dynamic QTL mapping are also presented. Power and sample size for QTL and *in silico* mapping studies are thoroughly explored, albeit not as extensively as for association mapping. Additional focus on power and sample size would have been useful because their importance for association mapping in crops is often undervalued by researchers.

Chapters 8 and 9 are dedicated to the theory and practice of marker-assisted selection (MAS) for genetic improvement in breeding populations. Nearly every mainstream variant of MAS such as foreground selection, background selection, gene pyramiding, and genome-wide selection is covered. One weakness is that the theory underlying genome-wide selection is not presented at a depth needed to fully understand and appreciate its application in plant breeding. Also, with the recent global emphasis on the breeding of bioenergy crops, it would have been worthwhile to include an extended section on the unique challenges that exist for MAS in perennial, outbred grass species. Multiple examples of MAS in several species are reviewed, but as the author accurately indicates, the translation of QTL studies to practice has significant bottlenecks that few public breeding programs can presently overcome. The chapter also highlights the importance of precise phenotyping as it relates to MAS—a welcomed inclusion that is seldom given the attention it merits. Chapter 10 centers on the analysis of genotype-by-environment interaction (GEI) and how it is considered in the development of stable, high yielding varieties. Also, the variety of models available for analyzing and dissecting QTL-by-environment interaction (QEI) are examined. This chapter closes on a high point with a focus on the application of genetic modeling to crop improvement.

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The numerous approaches available to isolate and functionally analyze genes are discussed in Chapter 11. Figure 11.1 is outdated because massively parallel signature sequencing (MPSS) and serial analysis of gene expression (SAGE) are essentially antiquated technologies with the advent of next-generation sequencing. Gene isolation methods based on recombination, expression, comparative, and mutagenesis analysis are also presented in excellent detail. Chapter 12 is devoted to the intricacies of plant transgenesis and the commercialization of transgenic crops. The many types of transformation vectors, selectable marker genes, reporter genes, and promoters used in *Agrobacterium*-mediated and particle bombardment transformation are comprehensively discussed. However, this chapter—like the majority of the book—is biased toward cereals. Chapter 13 focuses on the many facets of intellectual property rights and plant variety protection. Unlike most of the book, the section on international agreements could have been written more succinctly and in a manner more accessible to a reader with limited knowledge of patent and trade laws. The utilization of bioinformatics, data management and analysis, and decision support tools in molecular breeding are explored in Chapters 14 and 15. These two chapters deftly review the plethora of public plant databases and the types of selection and simulation tools presently available to a plant breeder.

This book is the result of nearly 10 years of preparation by Dr. Xu and leverages his previous co-authored book *Molecular Quantitative Genetics* (Xu and Zhu, 1994) and decades of experience in plant molecular genetics. The book has made great strides in narrowing the gap between genomics and plant breeding. Even though a portion of the reviewed genomics technologies may become eventually outdated, the multiple chapters covering quantitative genetics and MAS will undoubtedly continue to be relevant for many years to come. *Molecular Plant Breeding* is destined to be an essential handbook for the budding plant geneticist or the late career applied plant breeder. I look forward to using it as a reference and strongly recommend it as a graduate-level text for plant breeding.

References

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Michael Gore*
USDA-ARS, U.S. Arid-Land Agricultural Research Center, 21881 North Cardon Lane, Maricopa, AZ 85138, United States

*Tel.: +1 520 316 6358.
*E-mail address:*michael.gore@ars.usda.gov

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